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The Resistance of Yellow SWEET CORN HYBRIDS to Stewart's Wilt Disease

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On the Cover:

Symptoms of Stewart's wilt disease on sweet corn plants; healthy plant on the left, and two plants on the right exhibiting progressive stages of the disease.

THE RESISTANCE OF YELLOW SWEET CORN HYBRIDS TO STEWART'S WILT DISEASE

LANSING E. WILLIAMS and L. H. ROLSTON

Stewart's bacterial wilt is a serious disease of corn. The disease is usually found to some extent every year in the Eastern, Southern, and Corn Belt states. Many of the varieties of sweet, dent, flint, and popcorn are susceptible. The disease is especially destructive to sweet corn, particularly to the early, yellow, sweet varieties. Most of the white varieties of sweet corn, particularly those hybrids containing lines of Stowell's Evergreen and Country Gentleman (6) possess enough resistance to prevent serious loss, but the yellow sweet corn varieties vary considerably in their resistance.

The disease is caused by a bacterium, *Bacterium stewartii* Er. F. Sm., which enters the conducting tissues of the plants. The causal bacterium may overwinter in diseased plant residue or in seed from diseased plants, but this is not considered important as it also overwinters in the bodies of hibernating adult corn flea beetles, *Chaetocnema pulicaria* Melsheimer. When the flea beetles come out of hibernation during the early spring they feed on and inoculate the bacteria into the very young sweet corn plants. Later, the beetles transfer bacteria from diseased to healthy plants. In many cases the severity of Stewart's wilt during the growing season has been predicted by the severity of the preceding winter; the colder the winter the lower the incidence of Stewart's Wilt (1, 7).

The disease is most damaging to young sweet corn plants, as young susceptible plants which become diseased at this stage often wilt and die. Later leaf infections result in pale-green, long, irregular diseased streaks, portions of which become yellow-brown to dark and die. Badly diseased plants which do not die are stunted and form very small to no ears.

Stewart's wilt can be reduced or controlled by the use of insecticidal sprays to control the corn flea beetle (5). The use of antibiotics and other spray materials to control the bacterium has been studied and some control obtained but as yet none of these materials have been recommended (2, 4, 8). In small plantings the removal of diseased plants is helpful. The best and most economical method of control is the use of

the more resistant hybrids where possible. As reports of the resistance of the yellow sweet corn hybrids to Stewart's wilt have not always been derived from data obtained in the same or similar tests the relative resistance of hybrids is difficult to evaluate. The purpose of this investigation was to evaluate the resistance of a large number of the yellow sweet corn hybrids in the same tests and under approximately the same conditions in order to make recommendations and selections of hybrids to be planted in severe wilt areas.

METHODS—In the greenhouse tests, plants were grown in sterilized soil in wooden flats. At the 3 to 4-leaf stage they were clipped with scissors at the level of the coleoptile and the cut ends sprayed with a suspension of bacterial cells (3). Inoculum was prepared from 2 to 3 day-old yeast-extract-agar slant cultures of *B. stewartii*. The bacteria were suspended in water and the resulting suspension adjusted with an AC model Fisher Electrophotometer so that light transmission was reduced to 85 percent. In the two greenhouse experiments two isolates of the bacterium were used; Isolate No. 1 was isolated from diseased sweet corn in the Wooster area in 1955, and Isolate No. 2 from diseased sweet corn in the Wooster area in 1956. In the field tests (Marietta, Ohio) natural inoculations by the corn flea beetle were relied on.

Five replications of 20 plants each were planted in randomized plots for each hybrid. In the greenhouse, disease assays were made 7-9 days after inoculation; field disease assays were made approximately 1½ months after planting. The number of diseased plants were counted and the severity of symptoms rated on a scale of 0 to 5, where 0 represented a healthy and 5 a dead plant. The mean rating of all the plants of a hybrid in each test is expressed as the disease index.

For purposes of comparison the hybrids were divided into maturity groups which were designated with the name of a representative selection; Marcross group (maturing up to 72 days), Carmelcross group (maturing 73 to 79 days), Golden Cross Bantam group (maturing 80 to 86 days), and Golden Security group (maturing 87 or more days). These maturity dates were drawn from data of many sources and it is conceivable that one or more of the hybrids listed may be misplaced. Also, the maturation period may be different under different environmental conditions. The seed sources are designated as follows: (A) Associated Seed Growers, Inc., New Haven, Conn.; (C) Corneli Seed Co., St. Louis, Mo.; (H) Joseph Harris Co., Inc., Rochester, N. Y.; (Ho) Holmes Seeds, Canton, Ohio; (ML) Michael-Leonard Seed Co.,

Chicago, Ill.; (NK) Northup, King & Co., Minneapolis, Minn.; (R) Robson Seed Farms, Hall, N. Y.; and (W) F. H. Woodruff & Sons, Milford, Conn.

DISCUSSION—A large number of yellow sweet corn hybrids are available for planting today and their susceptibility to Stewart's wilt, one of the most severe sweet corn diseases, should be considered in any selection. In general, the early maturing hybrids are more susceptible to this disease, therefore in this study all hybrids included were grouped into maturity-length groups as closely as possible and the groups compared individually.

The problem of evaluating the resistance of a large number of plant varieties or hybrids to a disease is a difficult one due to variability in host and pathogen, the selection of study methods, the technical labor

Different sweet corn hybrids inoculated with the Stewart's wilt organism by the clip method. The photograph was taken approximately at the time of disease ratings in the greenhouse.

involved, and the interpretation of data obtained. The greenhouse testing of the susceptibility of very young plants and the evaluation of Stewart's wilt in field tests 1½ months after planting should extend over the range of the highest susceptibility of sweet corn to this disease. Inoculations by flea beetles of plants older than 1½ months should not produce a disease reaction as severe as earlier inoculations, but it may be possible that a particular hybrid might be an exception and be more susceptible during this older stage. The evaluation of wilt in older plants in the field tests may have overlooked the death and disappearance of very young plants but this young plant susceptibility should have been discovered in the greenhouse tests. As different races of a bacterium may differ in their pathogenicity spectrum the use of only one isolate in screening for disease resistance might give a different disease representation of the hybrids than when they are planted in areas where many different races of the causal bacterium may be encountered. With this problem in mind, two different isolates of *B. stewarti* were used in the greenhouse inoculations and natural inoculations by corn flea beetles in the field tests. The use of objective type measurements in assaying disease severity is very desirable, but in the case of Stewart's wilt these types of measurements are extremely difficult to obtain due to the undelimited and diffuse type of symptoms. The use of a subjective disease rating for this disease has been widely used and accepted and proved to be reproducible. The use of both disease incidence and severity, which takes into account the extent as well as severity of disease, gives a better insight into the disease-reaction of the hybrids than either criterion alone. The final classification of the hybrid disease resistance into a rank and rating gives the reader an easy method of comparing the average performance of any hybrid in a particular group, and the least significant difference (LSD) gives an opportunity for the comparison of individual hybrids.

A few hybrids which were very susceptible in one or more of the greenhouse tests exhibited good resistance in the field; the best example of this was in the case of the hybrid Tenderblonde (Table 3). The susceptibility in greenhouse and resistance in the field tests could be due to lack of inoculation in the field by corn flea beetle feeding, for in the greenhouse tests the plants were mechanically wounded and heavily inoculated. Perhaps in cases of this type the susceptibility of the hybrids in the greenhouse should be disregarded.

SUMMARY—The resistance of 87 yellow sweet corn hybrids to Stewart's wilt was studied in greenhouse and field tests. In the greenhouse the plants were inoculated with 2 different isolates of *B. stewarti* and natural inoculations by corn flea beetles were relied on in the field tests. The period of highest susceptibility of the sweet corn plants was encompassed by the inoculation and study of very young plants in the greenhouse and the rating of diseased plants in the field 1½ months after planting. The extent as well as severity of wilt was determined by estimating the severity of symptoms on plants which were diseased.

The hybrids Golden Beauty, Goldengainer, Golden Glory, N. J. 106, and Superchief (included in all 4 tests) were consistently as low in disease index and percentage as the best hybrid in each particular test.

As Stewart's wilt is a definite problem in sweet corn production, a hybrid's resistance to this disease should be a factor along with other criteria such as type of corn desired, yield, and quality in the selection of a hybrid to be planted.

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TABLE 1.—Reaction of sweet corn hybrids in the Marcross maturity group to Stewart's wilt

Hybrid and Seed Source	Greenhouse				Field				Rating‡	Av.§ Rank
	Bacterial Isolate #1		Bacterial Isolate #2		1956		1957			
	Disease* index	Percent† disease	Disease index	Percent disease	Disease index	Percent disease	Disease index	Percent disease		
Morning Sun (NK)	----	----	0.77	53.6	----	----	0.04	8.1	1	1.0
Golden Beauty (HO)	0.26	30.8	1.09	54.6	0.00	00.0	0.02	5.5	1	1.1
Spancross, Imp. (W)	0.12	21.1	0.91	53.5	0.25	20.4	0.10	15.2	2	1.6
NJ 106 (W)	0.22	20.7	1.16	54.9	0.06	11.3	0.07	9.9	1	1.8
Seneca Dawn (R)	0.19	23.4	----	----	0.45	26.2	----	----	5	3.3
Marcross (W)	0.34	36.9	0.53	46.0	0.20	25.0	0.12	23.1	3	3.4
Northern Cross (H)	----	----	1.27	62.2	----	----	----	----	5	4.5
Seneca Golden (R)	0.41	32.6	2.78	67.7	0.33	24.6	0.06	15.1	6	4.5
Seneca Daybreak (R)	0.36	33.1	2.62	72.3	0.37	26.0	0.15	20.5	6	5.8
North Star (H)	0.55	44.4	1.79	67.2	0.63	32.7	0.15	16.8	7	6.5
Sun-up (H)	----	----	1.76	62.8	----	----	0.16	21.4	7	6.5
Earliest Market King (NK)	0.56	43.2	----	----	0.95	43.2	----	----	7	7.5
Alphabest (ML)	0.78	48.6	----	----	1.97	54.6	----	----	7	8.5
Least Significant Difference at 0.05 Level	0.31	16.3	0.31	13.2	0.36	12.8	0.11	11.1		

*Disease index derived as the mean disease rating of all plants of a hybrid in each test; disease symptoms were rated on a scale of 0 to 5, where 0 represented a healthy and 5 a dead plant.

†Arc sin transformations were used to transform the original disease percentages.

‡The rating was calculated on the basis of the number of tests a hybrid was significantly poorer (either in percent disease or disease index) than the best hybrid in that particular test (the lower the rank the lower the disease reaction).

§Average rank was derived as the mean relative position of each hybrid (based on 1.0 as the best) with respect to disease index and percent in each test the hybrid was included.

TABLE 2.—Reaction of sweet corn hybrids in the Carmelcross maturity group to Stewart's wilt

Hybrid and Seed Source	Greenhouse				Field				Rating‡	Av.§ Rank
	Bacterial Isolate #1		Bacterial Isolate #2		1956		1957			
	Disease* index	Percent† disease	Disease index	Percent disease	Disease index	Percent disease	Disease index	Percent disease		
Golden Glory (NK)	0.17	19.3	0.29	34.5	0.01	3.0	0.02	3.5	1	1.0
Expt. Hybrid NK 199 (NK)	0.20	27.8	0.63	38.5	----	----	0.00	0.0	1	2.5
Asgrow Golden 22 (A)	0.15	24.8	----	----	0.17	20.9	0.01	6.8	2	3.0
Sencross, Imp. (W)	0.23	24.7	0.55	35.4	0.01	3.5	0.06	14.6	2	3.3
Evertender (ML)	0.23	29.9	0.63	39.7	----	----	0.01	2.7	1	3.7
New Earligold (W)	0.29	35.4	0.45	31.2	0.07	10.6	0.05	2.7	2	4.0
Seneca Beauty (R)	0.26	31.4	----	----	0.10	17.1	----	----	4	5.1
Barbecue (HO)	0.24	36.0	0.43	33.4	0.20	21.5	0.06	10.9	3	5.8
FM Cross (HO)	0.39	32.2	0.25	32.2	0.26	25.5	0.10	13.1	4	6.9
Golden Monarch (NK)	0.24	31.3	0.58	39.4	0.23	24.3	0.12	21.3	4	7.3
Gold Rush (C)	0.39	34.2	0.82	42.9	0.11	16.2	0.22	22.4	4	8.9
Seneca Arrow (R)	0.34	34.6	0.69	45.1	0.32	25.5	0.07	11.8	4	9.1

TABLE 2.—Reaction of sweet corn hybrids in the Carmelcross maturity group to Stewart's wilt—Continued

Hybrid and Seed Source	Greenhouse				Field				Rating‡	Av.§ Rank
	Bacterial Isolate #1		Bacterial Isolate #2		1956		1957			
	Disease* index	Percent† disease	Disease index	Percent disease	Disease index	Percent disease	Disease index	Percent disease		
Early Hybrid 0144 (W)	0.36	35.6	1.15	49.2	0.21	19.2	0.08	15.6	4	9.6
Tendergold (W)	0.25	15.4	1.04	51.6	0.54	33.8	0.25	25.4	5	9.9
Wonderful (H)	____	____	0.79	42.9	____	____	0.14	22.7	4	10.1
Carmelcross (H)	0.40	38.6	1.20	49.6	0.06	14.1	0.33	27.2	5	10.8
Hoosier Gold (W)	0.35	24.5	0.85	47.1	0.42	34.9	0.17	24.7	4	12.0
Goldspeed (ML)	0.49	34.5	____	____	0.74	33.8	____	____	7	12.9
Carmelcross, Imp. (HO)	0.62	48.6	____	____	0.54	34.0	____	____	6	14.4
Seneca Warrior (R)	0.78	59.2	____	____	0.73	31.8	____	____	7	14.4
Least Significant Difference at 0.05 Level	0.30	14.8	0.54	No. Sig. Difference	0.22	9.5	0.13	11.4		

*Disease index derived as the mean disease rating of all plants of a hybrid in each test; disease symptoms were rated on a scale of 0 to 5, where 0 represented a healthy and 5 a dead plant.

†Arc sin transformations were used to transform the original disease percentages.

‡The rating was calculated on the basis of the number of tests a hybrid was significantly poorer (either in percent disease or disease index) than the best hybrid in that particular test (the lower the rank the lower the disease reaction).

§Average rank was derived as the mean relative position of each hybrid (based on 1.0 as the best) with respect to disease index and percent in each test the hybrid was included.

TABLE 3.—Reaction of sweet corn hybrids in the Golden Cross Bantam maturity group to Stewart's wilt

Hybrid and Seed Source	Greenhouse				Field				Rating‡	Av.§ Rank
	Bacterial Isolate #1		Bacterial Isolate #2		1956		1957			
	Disease* index	Percent† disease	Disease index	Percent disease	Disease index	Percent disease	Disease index	Percent disease		
Expt. hybrid 1310 (NK)	----	----	0.43	32.0	----	----	0.01	3.4	1	1.0
Superchief (C)	0.84	44.2	0.36	37.6	0.01	2.8	0.00	00.0	1	1.1
Calumet (A)	0.49	36.4	0.49	41.7	0.00	00.0	0.01	2.8	2	2.2
Sixtypak (A)	----	----	0.54	45.3	----	----	0.00	00.0	3	3.3
Expt. hybrid 38697 (NK)	----	----	0.47	40.8	----	----	0.03	1.4	1	4.5
Expt. hybrid XP 126 (A)	----	----	0.37	41.7	----	----	0.03	4.1	3	4.8
Expt. hybrid 810 (NK)	----	----	0.52	26.9	----	----	0.04	4.1	1	6.3
Asgrow Golden 45 (A)	0.65	41.5	0.41	44.0	0.02	5.9	0.03	8.7	2	6.4
Sweetangold (C)	0.88	48.6	0.55	44.6	0.01	2.9	0.00	00.0	2	6.4
Ioana (W)	0.67	47.2	0.66	49.2	0.01	2.2	0.01	3.9	3	9.4
Goldengainer (ML)	0.80	54.6	0.44	32.4	0.07	9.6	0.03	8.5	1	9.4
Asgrow Golden 50 (A)	0.50	35.2	0.56	46.1	0.08	8.6	0.04	10.0	2	10.0
Iochief (W)	0.65	46.7	0.70	46.4	0.09	11.2	0.01	2.7	3	10.8
Yieldcross (ML)	0.58	40.7	0.63	41.9	0.18	12.3	0.09	7.6	3	11.6
Ill. Golden #10 (W)	0.83	49.8	0.65	43.5	0.02	8.6	0.03	8.7	3	11.6
Seneca Supermarket (R)	----	----	0.68	50.5	0.07	14.4	0.01	2.7	5	13.4
Tenderblonde (ML)	1.74	52.5	0.96	51.8	0.00	00.0	0.00	00.0	4	14.1
Sugar King (NK)	1.01	50.9	0.30	27.0	0.21	22.1	0.09	8.8	2	14.5

TABLE 3.—Reaction of sweet corn hybrids in the Golden Cross Bantam maturity group to Stewart's wilt—Cont.

Hybrid and Seed Source	Greenhouse				Field				Rating‡	Av.§ Rank
	Bacterial Isolate #1		Bacterial Isolate #2		1956		1957			
	Disease* index	Percent† disease	Disease index	Percent disease	Disease index	Percent disease	Disease index	Percent disease		
Seneca Chief (R)	----	----	0.78	50.2	0.17	17.5	0.00	00.0	5	14.8
Tendermost WR (ML)	0.80	47.4	0.58	38.9	0.17	22.8	0.06	14.7	3	15.0
Melocross (ML)	0.88	45.8	0.64	46.1	0.09	12.1	0.06	14.7	4	15.1
Victory Golden (W)	0.45	32.9	0.40	36.3	0.59	29.2	0.34	26.1	5	15.5
Golden Hybrid 2057 (W)	0.89	48.7	0.46	40.1	0.18	21.4	0.10	15.0	3	15.6
Plaingold (W)	1.42	60.8	0.53	45.9	0.10	17.1	0.02	8.0	5	17.0
Tenderchief (ML)	0.99	51.4	0.98	55.0	0.14	6.3	0.01	2.7	3	17.1
Creamcross (ML)	1.25	47.8	0.72	46.6	0.08	10.5	0.06	6.3	4	17.1
Tendermost 20 (ML)	0.93	42.9	0.48	46.1	0.13	17.5	0.17	21.8	5	17.3
Asgrow Golden 25 (A)	0.87	49.6	0.80	52.8	0.05	8.6	0.06	17 5	3	17.9
Longchief (ML)	0.98	52.3	0.89	51.6	0.19	14 4	0.00	00.0	4	18.1
Tempo (C)	1.04	52.2	0.46	42.7	0.25	17.8	0.14	14.1	5	18.6
Tendermost (ML)	----	----	0.56	42.7	0.29	21.9	0.09	18 8	7	20.1
Tenderfreezer (ML)	0.63	45.4	0.92	54.1	0.09	16.8	0.03	10.9	5	20.5
Lincoln (W)	0.70	51.7	0.65	45.8	0.24	24.8	0.15	18.3	6	21.1
Fine Gold (ML)	----	----	0.58	38.0	----	----	0.55	32.5	5	21.5
Gold Chief (ML)	----	----	0.76	46.6	----	----	0.07	12.6	8	21.5
Golden Cross 127 (A)	----	----	0.64	49.2	----	----	0.14	16.9	8	23.3

TABLE 3.—Reaction of sweet corn hybrids in the Golden Cross Bantam maturity group to Stewart's wilt—Cont.

Hybrid and Seed Source	Greenhouse				Field				Rating‡	Av.§ Rank
	Bacterial Isolate #1		Bacterial Isolate #2		1956		1957			
	Disease* index	Percent† disease	Disease index	Percent disease	Disease index	Percent disease	Disease index	Percent disease		
Iosquaw (C)	0.93	58.9	0.40	35.7	0.67	31.6	0.59	38.0	6	23.3
Golden Cross NC (NK)	0.65	47.8	0.87	52.1	0.36	28.7	0.13	17.3	6	23.6
Golden Cross Bant. (H)	0.87	52.3	0.62	45.9	0.48	30.3	0.22	26.9	8	23.6
Golden Cross WR (ML)	1.07	50.5	----	----	0.40	26.0	----	----	8	25.0
Expt. hybrid NK 72 (NK)	----	----	0.85	51.0	----	----	0.08	16.8	8	25.5
Lee (W)	1.25	55.5	----	----	0.30	19.4	----	----	8	26.0
Golden Bounty (NK)	1.05	56.4	----	----	0.33	29.7	----	----	8	28.0
Expt. hybrid KVF 54-45 (C)	1.00	54.1	0.83	50.1	----	----	0.42	34.2	7	29.0
Golden Cross VT 20 (NK)	1.21	54.1	0.94	60.3	0.23	22.7	0.24	24.2	8	29.8
Prosperity (C)	1.36	58.8	----	----	0.44	35.1	----	----	9	31.0
Expt. hybrid KVF 54-64 (C)	----	----	0.86	57.1	----	----	0.18	22.7	9	32.0
Least Significant Difference at 0.05 Level	0.62	15.8	0.62	15.8	0.26	14.1	0.15	10.1		

*Disease index derived as the mean disease rating of all plants of a hybrid in each test; disease symptoms were rated on a scale of 0 to 5, where 0 represented a healthy and 5 a dead plant.

†Arc sin transformations were used to transform the original disease percentages.

‡The rating was calculated on the basis of the number of tests a hybrid was significantly poorer (either in percent disease or disease index) than the best hybrid in that particular test (the lower the rank the lower the disease reaction).

§Average rank was derived as the mean relative position of each hybrid (based on 1.0 as the best) with respect to disease index and percent in each test the hybrid was included.

TABLE 4.—Reaction of sweet corn hybrids in the Golden Security maturity group to Stewart's wilt

Hybrid and Seed Source	Greenhouse				Field				Rating‡	Av.§ Rank
	Bacterial Isolate #1		Bacterial Isolate #2		1956		1957			
	Disease* index	Percent† disease	Disease index	Percent disease	Disease index	Percent disease	Disease index	Percent disease		
Aristogold B. Evergreen (ML)	____	____	0.53	33.0	0.05	6.6	0.00	00.0	1	1.0
Golden Yield (ML)	____	____	0.89	50.2	0.01	2.8	0.00	00.0	2	1.0
Huron (A)	____	____	0.35	33.0	0.22	18.2	0.06	16.7	4	1.5
Aristogold Bantam #1 (HO)	____	____	0.50	35.2	____	____	0.08	18.5	3	2.5
Golden Security (W)	____	____	0.48	36.7	0.21	20.1	0.19	23.6	5	3.2
Seneca Crown (R)	____	____	0.95	51.8	0.23	23.6	0.08	15.1	6	3.8
Paymaster (W)	____	____	1.10	56.5	0.51	28.7	0.09	15.5	7	4.5
Least Significant Difference at 0.05 Level	____	____	0.43	13.0	0.18	12.4	0.08	11.8		

*Disease index derived as the mean disease rating of all plants of a hybrid in each test; disease symptoms were rated on a scale of 0 to 5, where 0 represented a healthy and 5 a dead plant.

†Arc sin transformations were used to transform the original disease percentages.

‡The rating was calculated on the basis of the number of tests a hybrid was significantly poorer (either in percent disease or disease index) than the best hybrid in that particular test (the lower the rank the lower the disease reaction).

§Average rank was derived as the mean relative position of each hybrid (based on 1.0 as the best) with respect to disease index and percent in each test the hybrid was included.